3DSuit® Motion Capture System User Manual

Revision 1.2

Powered by SYNERTIAL

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1.INTRODUCTION

3DSuit full body Motion Capture System utilizes 15 (17) inertial 3D orientation sensors that measure real-time movements of each major bone segment of the body. From there, with the help of inverse kinematics, the system determines the location of each body joint and applies that to the skeleton of the avatar. Because inertial sensors rely on earth references of gravity and magnetic field, which exist everywhere, the suit itself is then able to operate virtually anywhere and without requiring any pre-operation setup.

With the introduction of temperature compensation and waterproof housing and cabling, **3DSuit** now also offers abilities to work underwater, in rain, in cold or hot weather; almost anywhere a person (or animal) would dare to go.

2.HARDWARE

2.1. 3D MINIATURE ORIENTATION SENSORS – INERTIAL MEASUREMENT UNITS (IMU)

The **Inertial Labs** multi-purpose 3D orientation sensors designed for use in real-time orientation tracking applications. It includes three types of sensing elements: tri-axial MEMS Gyroscopes, tri-axial MEMS Accelerometers, and tri-axial magneto-resistive Magnetometers. The 3D orientation sensors also comes equipped with an onboard processor and embedded orientation algorithms allowing for direct integration into systems without interfacing a PC.

Data from the Gyroscopes, Accelerometers, and Magnetometers, as well as the internal temperature sensor are gathered and processed by the on-board digital signal processor (DSP). The fusion algorithm processes these data and outputs the final orientation solution directly from the sensor. Data of the following types can be requested: raw inertial sensors data and/or quaternion data.

Each 3D orientation sensor module is individually calibrated in a special non-magnetic laboratory where reference accelerations, angular rates, and magnetic fields are applied to the device and measured at constant temperature. Additionally, temperature cycling is performed to obtain temperature calibration parameters for the gyro and accelerometer elements. Once fielded, 3D orientation sensor is able to be customer calibrated against soft- and hard-iron interference present in the end application.

3D orientation sensors specifications

Parameter	Units	Value
Number of sensors in 3DSuit		17
Output signals		Accelerations, Angular rates, Magnetic field, Quaternion
Output update rate (auto transmit)	Hz	20-2000
Start-up time	sec	<1
Heading		
Range	deg	0 to 360
Angular Resolution	deg	0.01
Static accuracy at constant temperature	deg	1
Dynamic Accuracy	deg, RMS	<2
Attitude		
Range: Pitch, Roll	deg	0 to 360
Angular Resolution	deg	0.01
Static accuracy at constant temperature	deg	0.2
Dynamic Accuracy	deg, RMS	1
Noise (@100 Hz)	deg, RMS	0.05
Gyroscopes		
Gyroscopes measurement range	deg/s	±1200 or ±2000
In-run Bias Stability at Constant Temperature	deg/s, RMS	0.1
Bias stability in whole Temperature Range	deg/s, RMS	1
Scale Factor Accuracy	%	0.5
Gyroscopes noise	deg/sec√Hz	0.03
Bandwidth	Hz	50
Accelerometers		
Accelerometers measurement range	g	±2 or ±16
In-run Bias Stability at Constant Temperature	mg, RMS	1
Bias Stability in whole Temperature Range	mg, RMS	3
Scale Factor Accuracy	%	0.15
Accelerometers noise	mg√Hz	0.2
Bandwidth	Hz	22
Magnetometers		
Magnetometers measurement range	Gauss	±2.0
Noise	µG/√Hz	150
Scale Factor Accuracy	%	0.1
Bandwidth	Hz	20
Environment		
Operating and storage temperature range	deg C	-40 to +85
MTBF	hours	35,000
Environmentally sealed (option)		IP67
Electrical		
Supply voltage	V DC	3.5 to 5.5
Power Consumption	W	0.3
Connector type	-	Binder 0931117104
Output Interface	-	TIA/EIA-485A (half-duplex)
Physical		
Size (with single-ended connector)	mm	50.7 × 14.5 × 9.2
Weight	gram	12

2.2.SENSOR BUS MOBILE PROCESSOR UNIT (SB-MPU)

The **Sensor Bus Mobile Processor Unit, SB-MPU,** is a multi-purpose processing platform designed to work with the **Inertial Labs** 3D orientation sensors.
The **SB-MPU** provides power to and receives data from up to 30 simultaneously connected 3D orientation sensors via TIA/EIA 485A serial protocol. The data is logged locally and can be transmitted in real-time to the PC via a standard mini-USB cable or wirelessly (WiFi).

The **SB-MPU** is equipped with hot-pluggable connector able to support a combined total of up to 30 orientation sensors and sensor bus extenders (**SB-Extender**) simultaneously. Input supply power is able to be provided by the Inertial Labs Battery Module or an equivalent DC supply. Power is then provided out to all of the connected sensor bus chains.

In addition to the currently supported feature set, the SB-MPU system is equipped with its own internal GPS receiver allowing for future support of GPS on board.

SB-MPU specifications

Parameter	Units	Value
MPU to PC wireless interface	-	802.11a/b/g/n or Bluetooth
MPU to PC for debug console		Virtual Serial Port over miniUSB, 115200/8/noPar/1/noFC
MPU to sensor bus interface	-	TIA/EIA-485A
Performance		
Internal Processor	-	Up to 1GHz (TI DM3730)
DDR Memory	-	512MB, 200MHz Mobile DDR SDRAM
Flash Memory	-	512MB, NAND flash memory +uSD card slot, up to 64GB
Environment		
Operating temperature	degC	0 to +85
Storage temperature	degC	-40 to +85
Electrical		
Input supply voltage	V	6.0 to 15.0
Output supply voltage	V	5±2%
Maximum output current	mA	3000
Power consumption (no sensors, WiFi off)	mW	500
Power consumption (no sensors, WiFi on)	mW	1500
Power consumption (18 sensors, WiFi on)	mW	7000
Sensor Bus Interface		
Standard	-	TIA/EIA-485A (half-duplex)
Baud Rate	bps	1000000
Byte Size	bits	8
Stop Bites	bits	1
Parity	-	No

2.3. SENSOR BUS SPLITTERS (SB-SPLITTER)

The **Inertial Labs Sensor Bus Splitter (SB-Splitter)** splits a single TIA/EIA-485 data bus into 3 TIA/EIA-485 buses. Intended for use with Inertial Labs 3D orientation sensors, the **SB-Splitter** supports the connection of multiple chains of devices to a single data acquisition and transmission unit such as the Inertial Labs SB-CU-W915, wireless controller, or the SB-CU-USB direct PC connection.

2.4. ANKER ASTRO-3E MOBILE BATTERY PACK

Anker Astro* is a line of portable external batteries designed for our modern mobile age. High capacity power and compact designs make these batteries a reliable power companion on the go.

** Astro is a trademark of Company ASTRO*

Features:

- 10000 mAh of capacity;
- Charges one device at maximum speed or two at 3A total;
- A lightweight, unassuming solution to life's daily power needs (0.59in thick). LEDs display just how much juice you've got left. Reliable lithium polymer core ensures quality, supplying you with more than 500 charge cycles during the course of its life;
- Input: 5V / 1.5A
- Package contents: Anker Astro 3E External Battery, 4 adapters, USB wire and travel pouch.

2.5. CISCO** LINKSYS E1200 WIFI ROUTER

*** CISCO is a trademark of Company CISCO*

The **Cisco** Linksys E1200** is one of the latest and best-reviewed basic Wireless-N routers, and it is no wonder why given its speeds of up to 300 mbps at this very affordable price. With up to 300 Mbps Wireless-N speeds (up to 6x faster than a Wireless-G router) and 4 fast Ethernet ports for wired connections.

3. SOFTWARE

MotionBuilder® & Unity® are Trademarks of Autodesk and Unity

Features:

- Kinematics Skeleton Software
- Easily record motion capture data
- Export to ***.bvh** format
- Real-time visualization, playback and editing of motion capture data
- Plug-in for seamless real-time integration with MotionBuilder® & Unity®

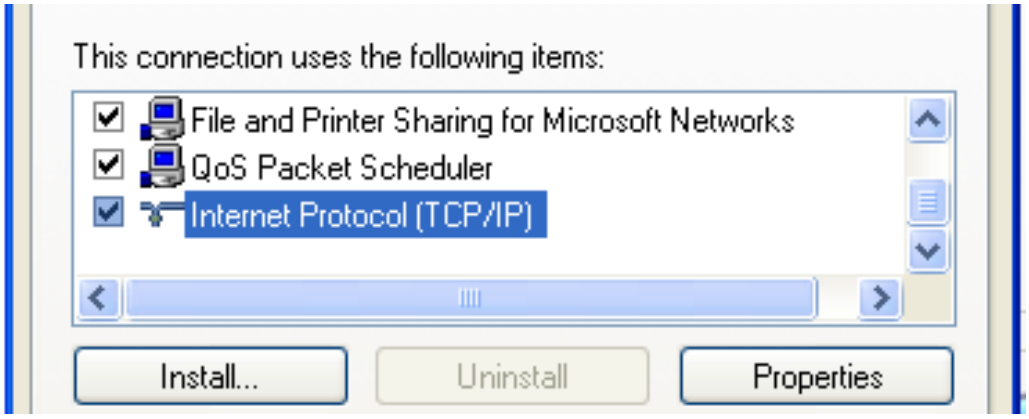
4. START-UP GUIDE

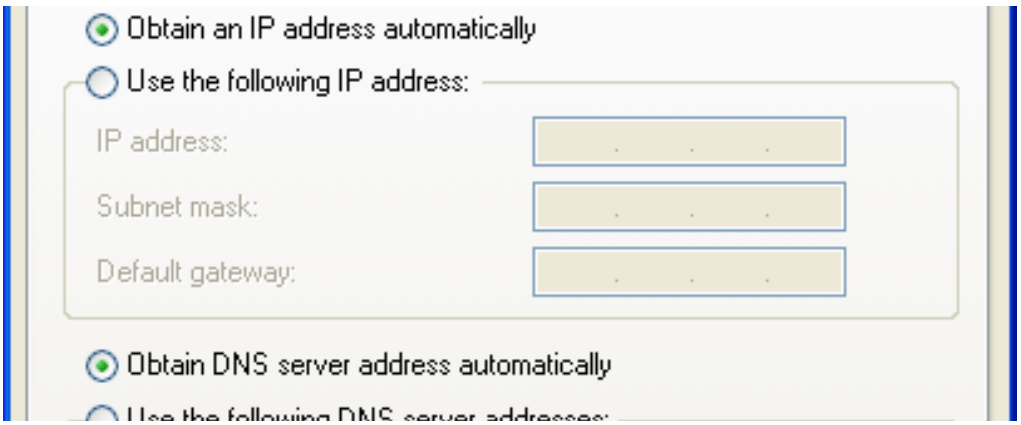
4.1. SETTING UP THE ROUTER

- Connect the Router (LAN 1) directly to the Ethernet port on your PC. If an internet connection is simultaneously required you must also connect a secondary Ethernet cable from an external internet source to the WAN port.

- Plug in the router and let it run through it's power up cycle.

- Your computer will detect the LAN network. You can go to *Control Panel/Network Connections* to view your networks. Double click on the newly discovered network in *Network Connections* and go to *Properties*. Under the *General* tab you will find a scroll-down list. Scroll down to *Internet Protocol (TCP/IP)*, highlight and click *Properties* to check that both *IP address* and *DNS server* are set to obtain automatically.





- To check that the computer has recognised the device you can open a command terminal (type *CMD* into *Run* as found in your Start bar) and Ping the router by typing: **Ping 192.168.11.1**

```
C:\Documents and Settings\ashley>ping 192.168.11.1

Pinging 192.168.11.1 with 32 bytes of data:

Destination host unreachable.
Destination host unreachable.
Destination host unreachable.
Destination host unreachable.

Ping statistics for 192.168.11.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

C:\Documents and Settings\ashley>
```

If there is no reply (Request timed out) from the router then the PC requires a reboot. The network adapter card could also be turned off.

```
C:\Documents and Settings\ashley>ping 192.168.11.1

Pinging 192.168.11.1 with 32 bytes of data:

Reply from 192.168.11.1: bytes=32 time<1ms TTL=64
Reply from 192.168.11.1: bytes=32 time<1ms TTL=64
Reply from 192.168.11.1: bytes=32 time<1ms TTL=64
Reply from 192.168.11.1: bytes=32 time<1ms TTL=64

Ping statistics for 192.168.11.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Documents and Settings\ashley>
```

When you get a reply from the router you can also Ping the MPU.
Switch the MPU on. Wait about 60 seconds and type: **Ping 192.168.11.xx**
(where xx is the MPU number found on the front of the device i.e. 30)

```
C:\Documents and Settings\Animazoo>ping 192.168.11.30

Pinging 192.168.11.30 with 32 bytes of data:

Reply from 192.168.11.30: bytes=32 time=33ms TTL=255
Reply from 192.168.11.30: bytes=32 time=9ms TTL=255
Reply from 192.168.11.30: bytes=32 time=9ms TTL=255
Reply from 192.168.11.30: bytes=32 time=9ms TTL=255

Ping statistics for 192.168.11.30:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 9ms, Maximum = 33ms, Average = 15ms
```

Note: *In situations where you are unable to ping the MPU please navigate to the router settings page via any browser at 192.168.11.1. Under LAN Interface / Show Clients you should be able to see all active wireless devices and this will allow you to double check the IP addresses of the MPU. If you continue to encounter connection issues then please check that there are no other wireless routers on in the vicinity that could be creating interference by connecting to the MPU. Switch off these other devices temporarily to see if they have any effect.*

4.2. 3DSUIT MAGNETIC DEVIATION COMPENSATION (MDC)

Each **3DSuit** Systemis individually calibrated in a special non-magnetic laboratory where reference accelerations, angular rates, and magnetic fields are applied to the device and measured at constant temperature. Additionally, temperature cycling is performed to obtain temperature calibration parameters for the gyro and accelerometer elements. Once fielded, **3DSuit** is able to be customer calibrated against soft- and hard-iron interference present in the end application.

What is MDC?

When a 3DSuit is operating in an open area in the absence of any ferrous metals there is no distortion effects on the earth's magnetic field. In reality, sensors are mounted on objects that most likely have ferrous materials nearby. The effects of ferrous metals will distort, or bend, the earth's field, which will alter the heading. These effects can be thought of as a magnetic field that is added to the earth's field. If the sensor is securely mounted in an object, the ferrous effects can be accounted for and removed from the magnetic readings. The current guide describes the procedure of how to compensate such magnetic deviations using the MDC application.

Before You Begin

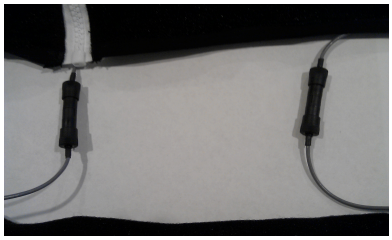
The MDC application can be run via SB-CU-USB.
Should you run into problems establishing the initial connection to the sensor upon startup of MDC please contact us via phone at +1-703-880-4222 or via email at support@inertiallabs.com.

MDC Instructions

Please run MDC according attached MDC instruction. It will take no more than 5 minutes to complete MDC and to reach 3DSuit best performance.

4.3.PUTTING ON THE 3DSUIT WITH EMBEDDED SENSORS

- putting on the 3DSuit;
- connect long sleeve shirt (upper part) and pants (lower part) by two binder connectors.

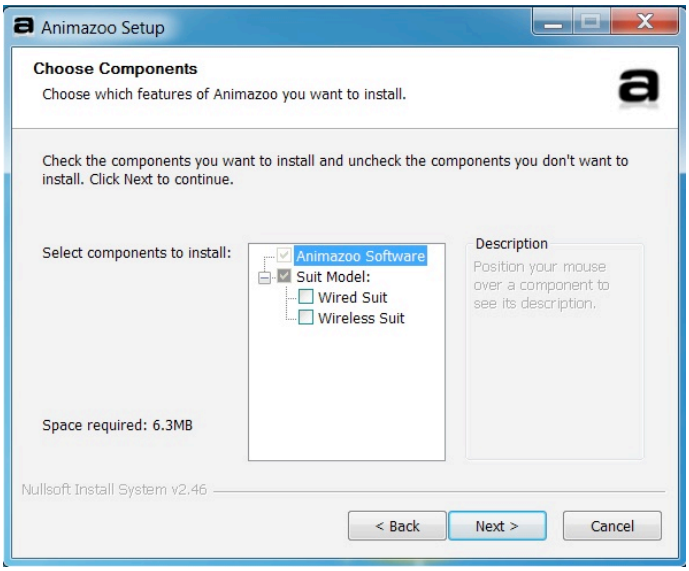


4.4. INSTALLING THE SOFTWARE

- Place the 3DSuit Software packs folders we have provided you onto your Desktop (or elsewhere as you decide more appropriate) and open them.

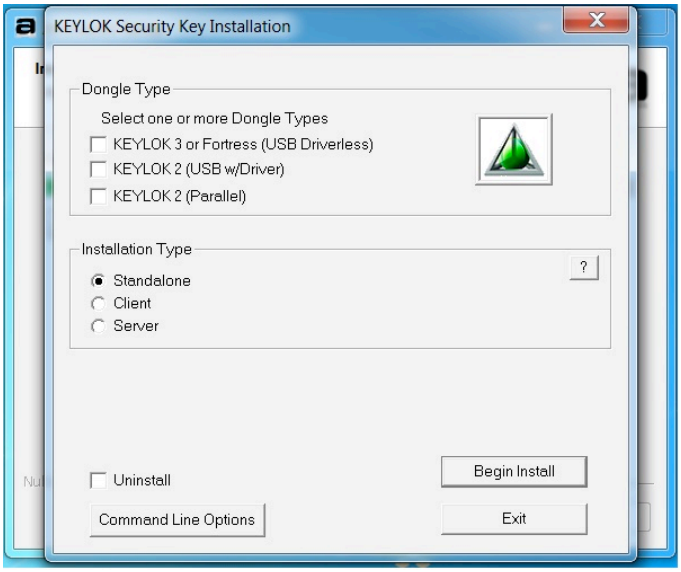
- Open the Install folder, and choose either 32-Bit or 64-Bit according to which you have installed on your operating system. Open the chosen folder and run either Setup32 or Setup64, whichever is in your folder.

- Follow the steps on the wizard shown until you get to the Choose Components screen. Here, choose either wired suit or wireless suit, according to what was purchased.


Animazoo Setup
Choose Components
Choose which features of Animazoo you want to install.
Check the components you want to install and uncheck the components you don't want to install. Click Next to continue.
Select components to install:
Animazoo Software
Suit Model:
Wired Suit
Wireless Suit
Description
Position your mouse over a component to see its description.
Space required: 6.3MB
Nullsoft Install System v2.46
< Back
Next >
Cancel

- After clicking next on the choose components screen, choose where to install the software. The default install location is "C:\\Program Files\Animazoo"

- After choosing your install path, you will get the Keylock Security Key Installation screen. Here, choose Keylock 3 or Fortress (USB Driverless), installation type Standalone.



- Once the installation is done, click finish

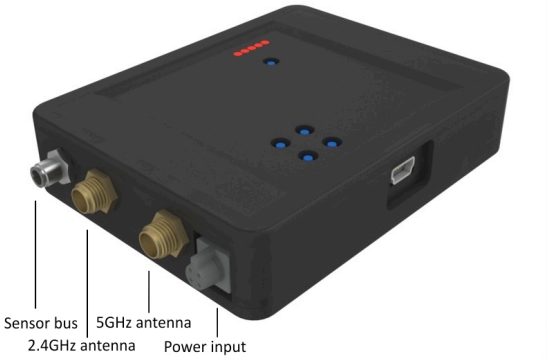
- To check installation, run AnimaFake and look for 'Normal'.

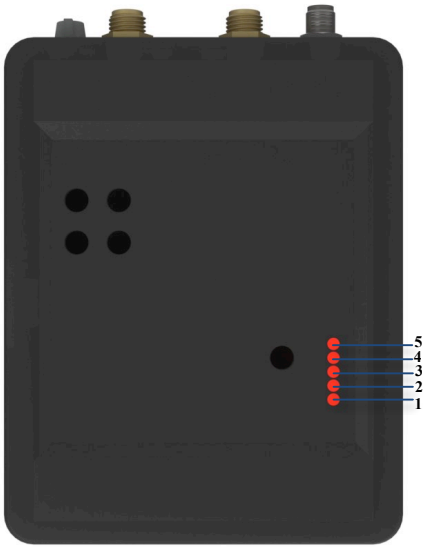
- To restart your PC

***Note**: If the command window closes itself please manually place GyroDrv.sys into C:\WINDOWS\system32\drivers and Animazoo.dll into C:\WINDOWS\system32*

4.5. RUNNING THE 3DSuit

4.5.1 CONNECT THE ANKER ASTRO-3E MOBILE BATTERY AND SENSORS BUS TO THE SB-MPU.





The order is:

Lights 1 + 2 will come on instantly and stay steady waiting for the 3rd light.

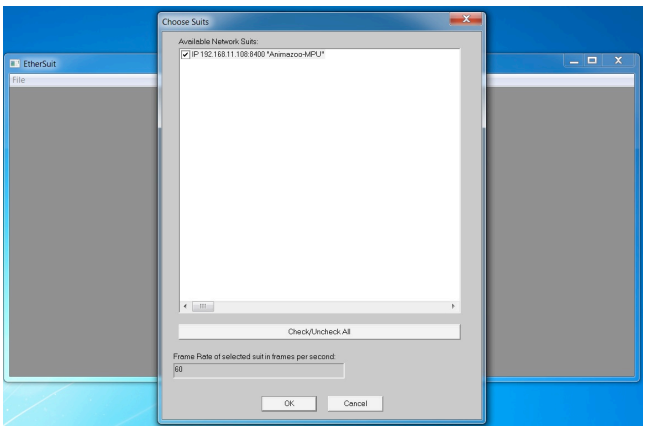
Light 3 will come on flashing and when it stops flashing, the router is connected and will automatically go to the next light

Light 4 is not used and will stay un-lit

Light 5 will come on flashing and when it stops flashing the SB-MPU has begun broadcasting stream of data in Wi-Fi

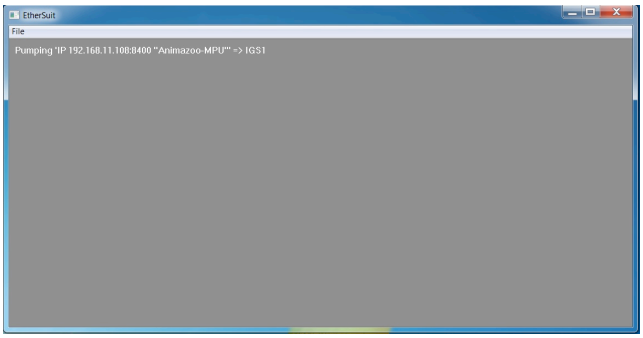
4.5.2 THEN OPEN THE WIRELESS SERVER (OR ETHERSUIT.EXE) AND ACCEPT BY CLICKING OK

- To run Ethersuit.exe, use windows explorer to go to where you installed the software (default C:\\Program Files\Animazoo), open the install folder, and launch Ethersuit.exe.



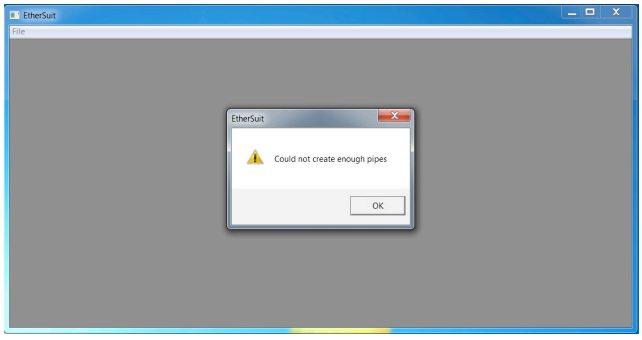
- If there is no suit detected, make sure you are on the correct network and the suit is turned on. You can find the suit again by going to File -> choose suit

- After choosing the suit, Ethersuit should display "Pumping 'IP …'"



- If Ethersuit pops up with the error "Could not create enough pipes", open up the command prompt in administrator mode (found under start -> accessories -> command prompt (rightclick -> run as administrator)) and type in "net start gyrodrv"

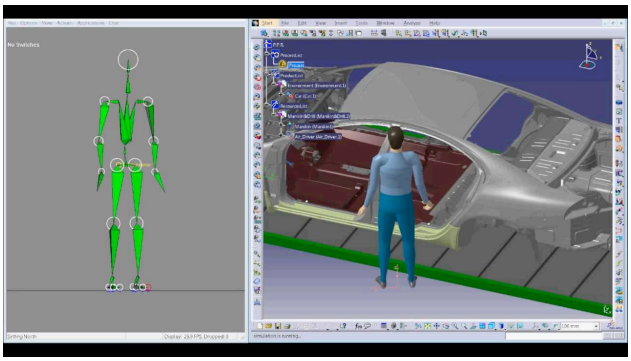
- After 5-30 seconds, the command prompt will respond with "The gyroDRV service was started successfully". If this message does not appear, verify that you installed the correct version of animazoo (32 or 64 bit). Once this message has appeared, you will be able to choose a suit successfully.



4.5.3 OPEN ANIMADEMO PROGRAM

4.5.4 FINALLY FACE SOUTH IN THE INITIALIZATION POSTURE AND PRESS 'N'

4.5.5 CHECK YOUR REAL-TIME REFERENCE MODEL



4.5.6 PRESS «ALT + R» TO START RECORDING

4.5.7 PRESS «ESC» TO STOP

4.5.8 PRESS «P» TO REPLAY.

***NOTE**: Make sure to save before recording the next take!*

Tips for Starting the 3DSuit

- For continued good battery life we recommend running the SB-MPU battery to empty and then fully charging whenever the opportunity arises.
- You will need to start the suit in clear line-of-site of the router. It is best to be stood about 4 feet away from the router during start up.
- Find a Magnetically Cleaning Space

Use the provided compass to check for magnetic interference at foot height, waist height and head height. Be on the look-out for air-conditioning units, power points, large metal objects or anything passing large electrical current.

You will need to Start the 3DSuit and 'North' in the 'magnetically cleanest' area possible.

- Stand still for Initialization
- Find north needed for initialization

This can be done with the compass that's provided or by a series of trial and error moves. By this I mean:

- Estimate which direction is South
- 'South' the 3DSuit by pressing «**N**» on the keyboard (or going Actions/Set North) whilst in AnimaDemo
- Lean forward as if bending to touch your toes to see if your shoulder alignment is straight or not. Judging by the slope of shoulders you will be able to re-South until you find the correct direction.
- Use the T shortcut to switch to 'top-down' view in AnimaDemo. This will help you discover whether or not when you lean forward your shoulders and spine are straight. This may sound like a lengthy process, but you will soon turn it into a quick one.

***Note**: It is good practicse to re-South prior to each recording you take therefore we would suggest that once you have located your South direction you mark the floor with masking tape or similar as a quick point of reference.*

System Maintenance

To ensure you get the best performance from your 3DSuit we've put together a simple list of do's and dont's.

Do:

- Drain your batteries often, if you can, before each charge. Leaving it on the charger indefinitely will reduce their life significantly. Take it off the charger as soon as the light is green
- Wash the Lycra 3DSuit in cold water and hang to dry
- Leave system in its case to avoid moisture and dust.

Don't:

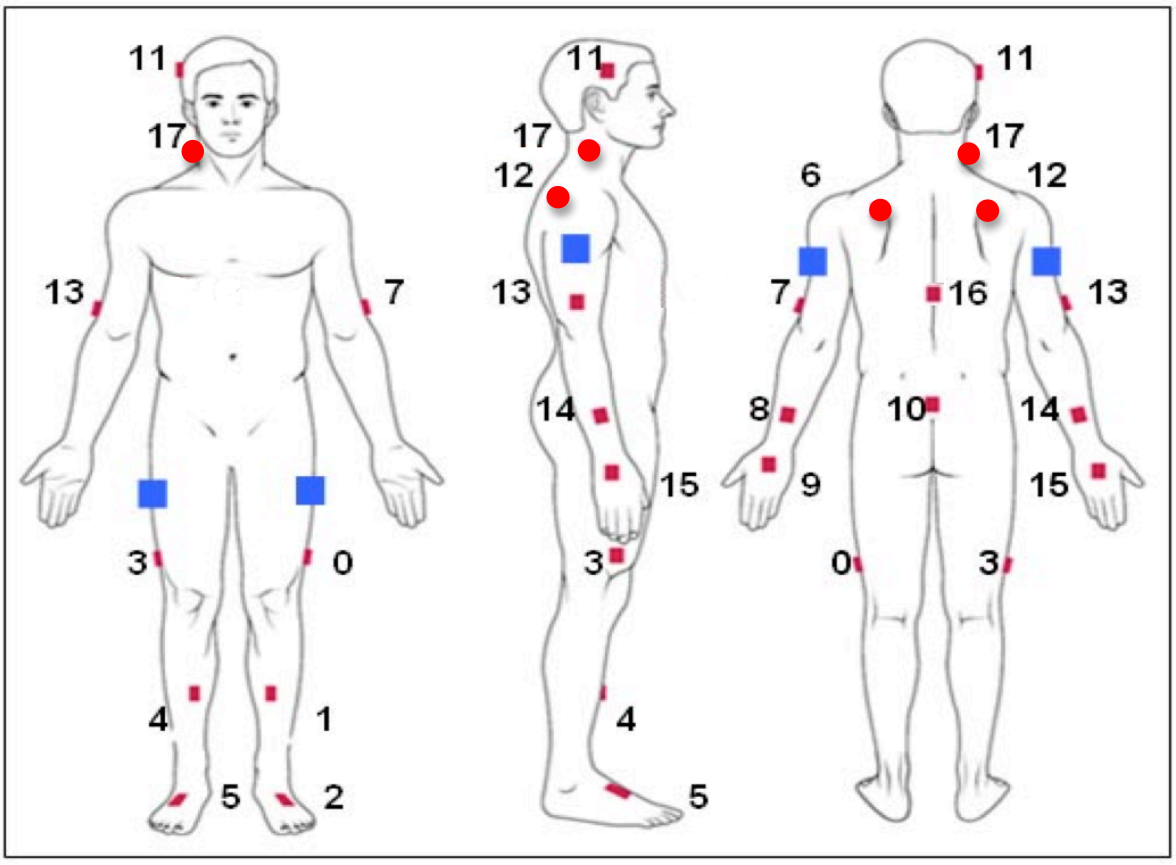
- Ensure that the 3D orientation sensors - aren't knocked by hard objects or dropped on hard floor. This can affect the 3D orientation sensors - factory pre-set calibration and will mean it has to be sent for recalibration.
- Don't let any part of the system get wet.
- Do not close the case with sweaty suit inside. Let it dry first.
- Don't pull cabling off the Lycra suit. Use the the 3D orientation sensors casing to pull it off the cloth. Ensure that Velcro patch is off the 3DSuit before pulling the casing off the Lycra suit.
- Careful when closing the hard case so as not to trap/damage any of the cabling.

Setting up your hardware

The main components of your system's hardware include 17 inertial 3D orientation sensors, cabling, SB-MPU and two SB-Splitters. It is vital that the 3D orientation sensors - are accurately placed to best avoid known data artefacts to achieve the best data possible from your system.

3D Orientation Sensors Placement

The diagram below depicts the correct anatomical placement of each sensor:



NOTE:

- *place sensors on the upper legs (# 3 & 0) and upper arms (# 13 & 7) as shown by Red markers above. However when the subject has large muscles on those limbs, use the blue marker placements to insure the most accurate capture of motion;*
- *sensors #6, 12 and 17 are for 18 3D orientation sensors 3DSuit model.*

Enjoy your 3DSuit Motion Capture System!